

## IN THE SPECIFICATION

Please replace the paragraph beginning at page 2, line 33 with the following:

Generating a PTAT signal is commonly accomplished by operating two bipolar transistors at different current densities. It is well known that for two transistors operating at different current densities, the difference in base-emitter voltages is given by:

$$\Delta V_{BE} = \frac{kT}{q} \ln J1/J2 \quad \Delta V_{BE} = \frac{kT}{q} \ln (J1/J2) \quad \text{Eq. (1)}$$

where  $k$  is Boltzman's constant,  $T$  is absolute temperature,  $q$  is the charge of an electron, and  $J1$  and  $J2$  are the current densities of the two transistors. (The expression  $kT/q$  is also known as the thermal voltage  $V_T$ .) Thus, the differential voltage is proportional to absolute temperature (PTAT). The current densities  $J1$  and  $J2$  are typically made unequal by operating the two transistors at the same current and making the emitter areas unequal. Alternatively, the same result could be obtained by setting the emitter areas equal and operating the transistors at unequal currents. Since this cell is based on the difference between the base-emitter voltages of two transistors, it is often referred to as a “ $\Delta V_{BE}$ ” cell.

Please replace the paragraph beginning at page 3, line 17 with the following:

The bases of transistors  $Q1$  and  $Q2$  are connected together, while the emitters are connected through resistor  $R2$ . Transistors  $Q1$  and  $Q2$  are loaded by resistors  $R_{C1}$  and  $R_{C2}$  which are typically selected to be equal. High gain amplifier  $A$  drives the bases of  $Q1$  and  $Q2$  so as to equalize the currents  $I_{C1}$  and  $I_{C2}$ . The emitter areas  $A1$  and  $A2$  of transistors  $Q1$  and  $Q2$  are unequal, and since  $I_{C1} = I_{C2}$ , the transistors operate at different current densities  $J1$  and  $J2$ . Thus, according to Eq. (1),  $V_{BE}$  for the two transistors are unequal, and the difference voltage  $\Delta V_{BE}$  appears across resistor  $R2$ . The current  $I_P$  through  $R2$  is therefore given by  $I_P = \Delta V_{BE} / R2$ . However, since the current through both transistors is equal, the current through  $R1$  is twice the current through  $R2$ , and the voltage  $V_{PTAT}$  across  $R1$  is:

$$\cancel{V_{PTAT} = 2 (R1/R2) V_T \ln A1/A2} \quad V_{PTAT} = 2 (R1/R2) V_T \ln (A2/A1) \quad \text{Eq. (2)}$$

Thus the voltage across  $R1$  is proportional to absolute temperature since  $V_T$  is proportional to absolute temperature, i.e.,  $V_T = kT/q$ .

Please replace the paragraph beginning at page 8, line 8 with the following:

The loop equation for the loop including the  $\Delta V_{BE}$  cell may be written as follows:

$$IR_X + V_{BE1} = V_{BE2} + (I_1 + I)R_V \quad \text{Eq. (3)}$$

where  $V_{BE1}$  is the base-emitter voltage of Q41, and  $V_{BE2}$  is the base-emitter voltage of Q42.

Since  $V_{BE1} - V_{BE2} = \Delta V_{BE}$ , and  $\Delta V_{BE} = V_T \ln(M)$ , the equation may be rearranged as follows:

$$V_T \ln(M) = V_{BE1} - V_{BE2} = IR_V + I_1 R_V - IR_X \quad \text{Eq. (4)}$$

As a convenient example, assume  $R_X = 2R_V - R_G$  and continue to rearrange:

$$\cancel{V_T \ln(M) = IR_V + I_1 R_V + I(2R_V - R_G)} \quad V_T \ln(M) = IR_V + I_1 R_V - I(2R_V - R_G) \quad \text{Eq. (5)}$$

$$V_T \ln(M) = I_1 R_V - IR_V + IR_G \quad \text{Eq. (6)}$$

Since  $I$  and  $I_1$  are effectively equal, the  $I_1 R_V$  and  $IR_V$  terms cancel, and it becomes apparent that the current  $I$  is determined by the parameter  $R_G$ :

$$I = V_T \ln(M) / R_G \quad \text{Eq. (7)}$$

Some further example values will now be discussed to provide more insight into the operation of the embodiment of Fig. 8, but the inventive principles not limited to any of these examples. If  $R_G < 2R_V$ , then  $R_X$  would be negative, so assume  $R_G = 2R_V$ .  $R_X$  then becomes zero. The voltage at the emitter of Q42 (node N42) is  $2IR_V$  (more exactly  $(I + I_1)R_V$ ) and is PTAT. The voltage drop across  $R_Y$  is  $I_1 R_Y$ . These two voltages added to  $V_{BE2}$  are the bias voltage  $V_{BIAS}$ :

$$V_{BIAS} = I_1(R_Y + R_V) + IR_V + V_{BE2} \quad \text{Eq. (8)}$$

Defining  $W = (R_Y + R_V)$  and  $V = R_V$  provides a convenient way to understand how the various resistor values affect the relative amount of compensation the replication transistor contributes to  $V_{BIAS}$ . The factor  $V$  determines how much weight is given to the current  $I$ , whereas the factor  $W$  determines the amount of contribution from the compensation current  $I_1$ . Using a non-zero value for  $R_X$  provides additional flexibility in controlling the amount of compensation.